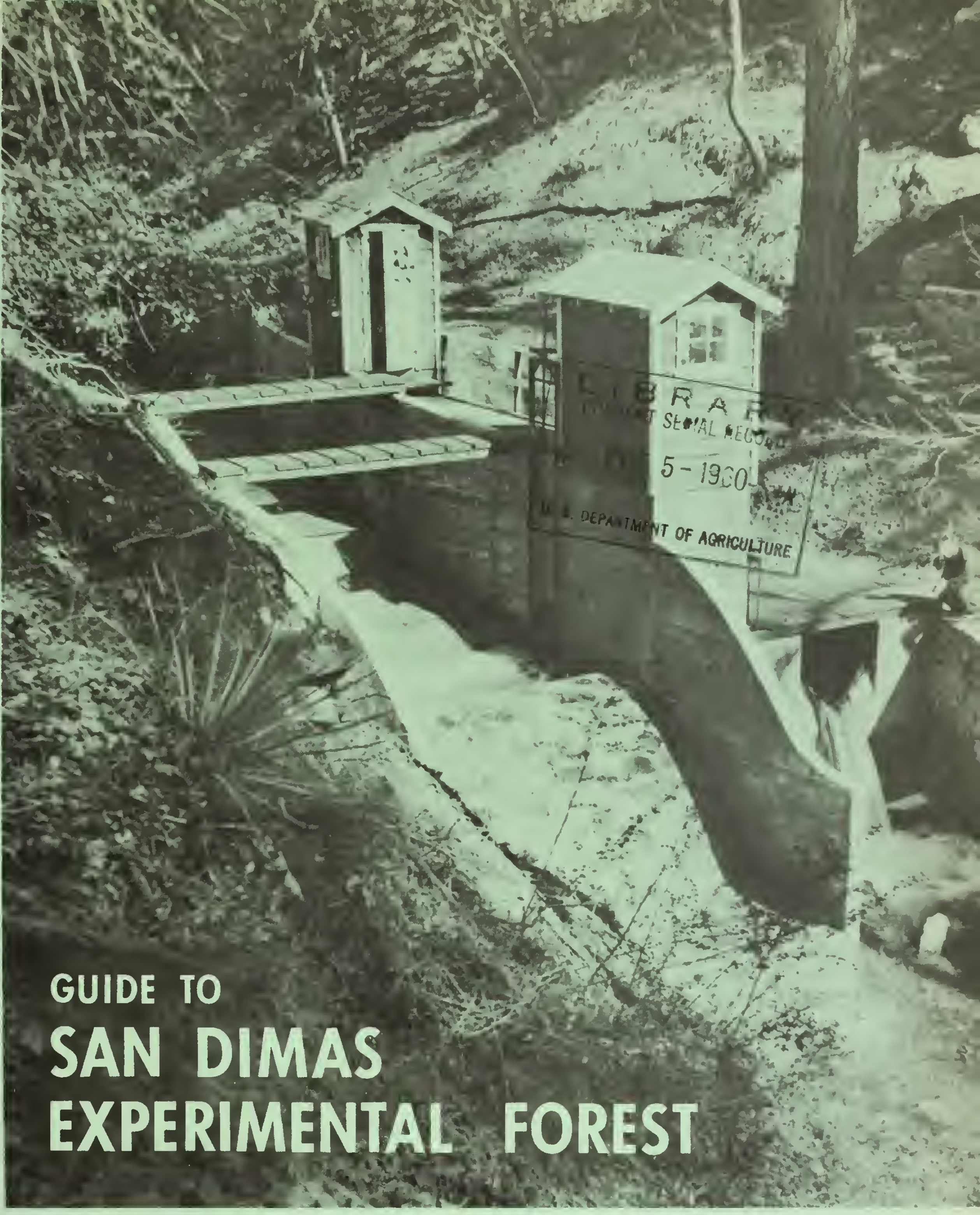


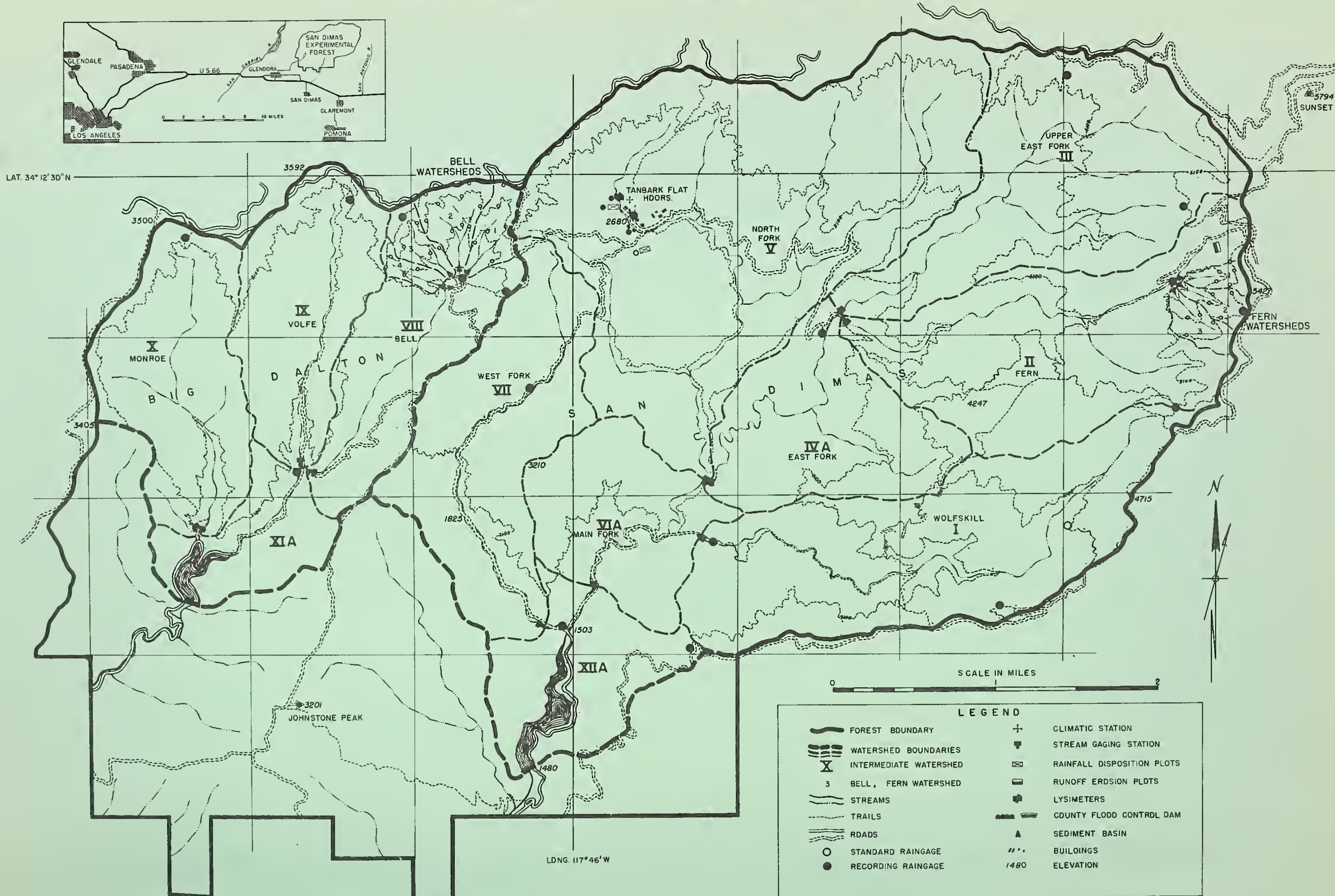
GUIDE TO SAN DIMAS EXPERIMENTAL FOREST

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

in cooperation with

DIVISION OF FORESTRY
DEPARTMENT OF NATURAL RESOURCES
STATE OF CALIFORNIA

SAN DIMAS EXPERIMENTAL FOREST



A GUIDE TO THE SAN DIMAS EXPERIMENTAL FOREST

By

J. D. Sinclair, E. L. Hamilton, and M. N. Waite

California Forest and Range Experiment Station

STAFF

California Forest and Range Experiment Station - Keith Arnold, Director

Division of Watershed Management Research - Walt Hopkins, In Charge
J. D. Sinclair, Staff Specialist

San Dimas Experimental Forest - J. R. Bentley, In Charge

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WATER PROBLEMS IN SOUTHERN CALIFORNIA

Water is generally recognized as the most important factor affecting the existence and future growth of the great metropolitan, agricultural, and industrial developments in southern California.[1/] The phenomenal growth of this region in 55 years, indicated by an increase in population from 321,000 in 1900 to more than 7,000,000 in 1955, has brought about serious problems of which water supply and flood regulation are paramount.

Natural conditions of climate, topography, and vegetation contribute to the severity of local water problems. Most of the region is hot and dry from May to October and subject to intense rains in other months. Rugged mountains that rise abruptly near populated and highly developed valleys are sources of floods that have caused extensive damages downstream. Brush, also known as chaparral, is the dominant vegetation on the mountains below elevations of about 5,000 feet. Open coniferous forests form the principal cover at higher elevations. During the summer seasons the vegetation, especially the chaparral, becomes very flammable. When mountain watersheds are denuded by fire the magnitude of floods from them is sometimes greatly increased.

Water Supply Problems

Early settlers in southern California obtained water from streams and springs whose sources were the nearby mountains. Needs for greater supplies were met by digging shallow wells, some of which produced artesian flows, and by developing water-collecting tunnels and small storage reservoirs in the foothills. Later the growing demands for water made it necessary to sink deeper wells in the valleys to reach water tables lowered by the increased draft upon them. Continuing overdraft in recent years has lowered the water tables near the coast and permitted sea water intrusion in certain basins, with resultant loss of usable water. In some other localities curtailment of water use has been necessary, particularly during periods of low rainfall.

Growing water needs led to importation of water into southern California, starting in 1913. Aqueducts have been built to bring water from the eastern slopes of the Sierra Nevada and from the Colorado River, each more than 250 miles distant. These developments, made at tremendous cost, are indicative of the value of water in a region where other natural advantages abound.

Southern California now contains about 55 percent of the State's population, but its streams carry only about 2 percent of the State's water supply. In 1950 southern Californians used more than 3-1/2 million acre-feet of water. About half of this amount was used for irrigation in the Imperial

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1/ Southern California is considered here to include the counties of San Luis Obispo, Santa Barbara, Ventura, Los Angeles, San Bernardino, Orange, Riverside, San Diego, and Imperial, with a total area of 31,125,000 acres, or about 31 percent of the State of California.

and Coachella Valleys, and came from the Colorado River. About 70 percent of the water supply for the remainder of the region came from local watersheds. Although portions of southern California are supplied with imported water, supplies from the local mountains are relied upon in many areas.

Flood Regulation Problems

Southern California also has serious flood problems. Major floods caused by heavy winter rains usually carry large quantities of debris which greatly increases the difficulties and costs of flood regulation. This debris comes from the rugged and geologically unstable mountains where erosion of soil and rock is naturally severe. Flood flows, bulked with mud and rock, have caused losses of life, and property damages amounting to millions of dollars. Repeated experiences have shown that destruction of the vegetation on the mountains by fire may greatly increase surface runoff and erosion, thereby adding to the magnitude of floods and the damages done by them. Disturbance of the vegetation and soil by the construction of highways in the mountains also has accelerated erosion in some watersheds. Other serious consequences of floods are the siltation of reservoirs and the wastage to the sea of water that cannot be caught for use. Water-spreading, a method of replenishing underground supplies, cannot be done with flows carrying a debris load.

Downstream flood control works such as debris basins, reservoirs, large retarding basins, and channel improvements have been constructed by Federal and local agencies. Approximately 300 million dollars have been expended for these works. The completion of similar works that are planned will raise total expenditures for flood regulation in southern California to more than 600 million dollars.

Protection of Mountain Watersheds

Before 1892 foresighted leaders in southern California recognized the relationship of mountain watersheds to the water problem in this region. Through the efforts of these leaders several forest reserves were established between 1892 and 1907 for the primary purpose of protecting local watersheds to "insure favorable conditions of water flows" as well as the "preservation of timber for the use and necessities of citizens of the United States." These reserves later became the national forests of southern California, administered by the Forest Service of the U. S. Department of Agriculture. Thus, national recognition was given to the protection of about 3 million acres of public watershed lands in southern California.

Watershed Research

The need for information concerning the influence of watershed conditions upon water supply, floods, and erosion prompted the Forest Service to start preliminary studies in southern California about 40 years ago. The studies were continued by the California Forest and Range Experiment Station in 1927, soon after its establishment. The San Dimas Experimental Forest was set up as a center for watershed research in 1933, with the cooperation of the State of California, county and municipal agencies, conservation groups, water companies, engineers, and agriculturists.

SAN DIMAS EXPERIMENTAL FOREST

Monthly Climatic Data

Tanbark Flat Field Headquarters (Elevation 2,800 feet)

Month	Rainfall 27-year average	Evaporation 20-year[1] average	Air temperature[2] Absolute maximum		
			Absolute maximum	Absolute minimum	Mean
	inches		degrees		
October	1.1	5.8	102.0	25.5	60.9
November	2.2	3.7	87.0	28.0	53.8
December	5.3	2.5	84.5	21.5	48.9
January	5.1	2.3	84.0	18.0	46.4
February	5.6	2.5	83.0	22.0	47.1
March	4.6	3.5	80.5	24.0	48.8
April	2.4	4.2	90.5	26.0	53.3
May	0.5	5.8	100.0	28.5	57.1
June	0.1	7.0	101.0	33.0	62.5
July	T	10.0	104.0	39.0	71.6
August	0.1	9.9	107.0	38.0	72.1
September	0.3	8.4	108.5	37.5	69.6
Annual	[3] 27.3	65.6	108.5	18.0	57.6

1/ Weather Bureau type evaporation pan.

2/ Air temperature for 22 years of record.

3/ 27-year average based on San Dimas Experimental Forest records 1933 through 1955, and Los Angeles County records for the 5-year period 1928 through 1932.

SAN DIMAS EXPERIMENTAL FOREST

Annual Climatic Data

Tanbark Flat Field Headquarters (Elevation 2,800 feet)

Year	Rainfall	Evaporation 1/	Air temperature: Absolute maximum	Air temperature: Absolute minimum	Air temperature: Annual mean
	inches	inches	degrees	degrees	degrees
1933-34	24.4		104.0	30.0	60.9
1934-35	34.8		96.0	25.0	56.8
1935-36	24.3	67.6	101.5	29.0	57.7
1936-37	43.8	67.9	98.0	19.0	57.9
1937-38	48.1	65.8	101.0	30.0	58.7
1938-39	27.0	72.6	100.5	22.0	57.8
1939-40	22.0	77.7	99.5	30.5	59.4
1940-41	48.2	61.4	95.5	32.0	58.1
1941-42	16.7	70.0	99.0	25.0	56.3
1942-43	45.2	70.1	101.5	26.5	58.1
1943-44	33.5	59.8	103.0	27.0	56.1
1944-45	29.7	59.9	97.0	26.5	55.3
1945-46	27.0	63.4	100.0	27.0	58.0
1946-47	27.6	63.5	100.5	27.0	58.3
1947-48	15.8	70.0	103.5	24.0	56.2
1948-49	16.9	64.7	100.0	18.0	54.5
1949-50	20.8	64.1	107.0	22.0	57.5
1950-51	11.5	72.4	102.0	23.0	59.6
1951-52	41.1	57.5	98.5	22.5	56.7
1952-53	15.5	61.5	105.0	25.5	57.7
1953-54	24.9	61.4	102.0	28.0	58.8
1954-55	19.9	61.4	108.5	24.0	57.3
Average 2/	3/ 28.1	65.6	108.5	18.0	57.6

1/ Weather Bureau type evaporation pan.

2/ Annual average or range.

3/ 22-year average based on San Dimas Experimental Forest Records.

THE SAN DIMAS EXPERIMENTAL FOREST

The San Dimas Experimental Forest covers 17,000 acres within the Angeles National Forest, and is situated on the southern slope of the San Gabriel Mountains in the San Dimas and Big Dalton drainages. Selection of the research area was based upon the following features: (1) It is representative of much chaparral-covered mountain land in southern California; (2) it is separated from the main San Gabriel Mountain mass by deep canyons which minimize the possibilities of underground water movement into the area; (3) the two major drainages contain a number of tributary watersheds of intermediate size, and many small watersheds, which can be studied; (4) the vegetation includes different chaparral associations as well as different ages of cover; and (5) the existence of San Dimas and Big Dalton dams, built and maintained by Los Angeles County Flood Control District, provides measuring controls for the major drainages.

Research Objectives

Watershed research on the San Dimas Experimental Forest, and related studies conducted elsewhere in southern California, have two broad objectives. The first is to determine how watersheds function: what happens to the precipitation, and how water and soil movement are influenced by conditions of vegetation, soil, geology, and topography. The second is to develop methods of watershed management that will ensure the maximum yield of clear, usable water with the minimum of flood runoff and soil erosion. Most research on the San Dimas area, thus far, has been directed toward the first objective.

Study of Watershed Functions

The following studies are designed to learn about watershed functions.

1. Climate--Climatic records, including air temperature, relative humidity, wind direction and velocity, and evaporation, were collected for several years at seven stations within the San Dimas Forest at altitudes ranging from 1,500 to 5,200 feet. Having thus established the local climatic pattern, records are being continued only at the Tanbark Flat field headquarters. Measurement of precipitation on the area was provided for originally by a network of 310 rain gages. Most of the gages were placed on contour trails. Supplementary studies were made to determine suspected errors in the rainfall sampling system. The results indicated that rain gages tilted and oriented normal to watershed slopes, sampled the rainfall more accurately than the original network of vertical gages. Accordingly the first sampling system was replaced in 1950 with a network of 120 tilted gages. This network in turn was reduced to 20 gages in 1954 following further analysis of accumulated data. Gages in the present rainfall sampling system are chiefly recording gages which supply both the amount and the rate of rainfall.

2. <u>Streamflow</u>--Measurements of runoff from the two major drainages are obtained from records of flow into San Dimas and Big Dalton reservoirs. These major watersheds have been divided into 10 tributary "intermediate watersheds" and contain two groups of small watersheds, the Bell and Fern series.

Each intermediate and small watershed contains a gaging station at its mouth. The gaging stations for the intermediate watersheds consist of three units--a 90-degree V-notch weir to measure low clear water flows; a steel San Dimas type flume to record ordinary storm flows that carry some debris; and a large concrete flume to record high flood flows. Two of the large flumes are Parshall type structures, one contains a step-type gaging section of U. S. Geological Survey design, and seven are San Dimas type flumes. Stream gaging stations for the Bell and Fern small watersheds consist of a V-notch weir and a San Dimas flume. Difficulties encountered in measuring debris-laden flows made it necessary to develop the San Dimas flume. This type of flume has proven satisfactory for the measurement of such flows.

As of 1954 continuous records of streamflow are being taken for only six of the intermediate watersheds. The four discontinued stations, however, were equipped with instruments to indicate maximum streamflow peaks.

3. <u>Watershed Erosion</u>--Measurements of the amount of material eroded from the major watersheds are obtained by periodic surveys of sediments deposited in San Dimas and Big Dalton reservoirs. Measurements of material eroded from the Bell and Fern small watersheds are made in concrete-lined basins at the mouth of each watershed.

4. <u>Surface Runoff and Erosion</u>--Studies of surface runoff and erosion on slopes, as differentiated from entire watersheds, are being made on 1/40-acre plots. Each plot is equipped with a trough to catch surface runoff and eroded material, and some record runoff synchronously with rainfall.

The nine Fern plots are situated on a 50 percent slope at an elevation of 5,000 feet in a cover of live oak. The vegetation had been unburned for more than 50 years prior to 1938 when a fire swept over this area. Surface runoff and erosion had been negligible before the vegetation was burned, but both were increased markedly for three years following the fire. After that the regrowing cover of native plants again protected the soil, and surface runoff and erosion became negligible.

Measurements of runoff and erosion also are being obtained from other plots in connection with studies of rainfall disposition.

5. <u>Disposition of Rainfall</u>--Studies were started in 1952 to determine the disposition of rainfall under covers of grass, brush, and pine. The work is being conducted on five triplicate sets of plots at Tanbark Flat. Twelve plots are situated on slopes of approximately 35 percent at an elevation of 2,800 feet in a dense chaparral cover unburned since 1919. The brush was removed from six of the plots in 1952 and replaced with grass. At that time three more plots were established in a Coulter pine plantation near Tanbark Flat.

Three series of electrical soil moisture units are installed in the center plot of each triplicate set, at regular depth intervals from 1-1/2 inches to bedrock which, in some places, is more than 16 feet below the surface. These units and other instruments make it possible to determine the total precipitation reaching the soil, the quantities of surface runoff, infiltration, and evapo-transpiration, and the amount of precipitation which percolates through the soil to the underlying rock. The results obtained here will aid in future investigations concerning the management or change of vegetation on entire watersheds.

6. Evapo-transpiration--Evaporation of water from vegetation and soil, including that transpired by the plants, is being studied in soil-filled tanks called lysimeters. The San Dimas lysimeter installation near Tanbark Flat consists of 26 concrete tanks, each 10.5 x 21 feet in area and 6 feet deep, with surface and bottom slopes of 5 percent. These large lysimeters are augmented by more than 100 smaller metal tanks for supplementary studies. All are filled with a uniform mixture of local soil. One large lysimeter is kept bare, and several species of bunchgrass are planted in two others. Groups of from two to five other lysimeters are occupied by pure stands of five shrubs and Coulter pine, all native to these mountains. Runoff and seepage are caught and measured in tanks set in a concrete tunnel underground. Electric water level transmitters permit the rates of runoff and seepage to be recorded on clock-driven charts. Soil moisture at various depths in the lysimeters is measured frequently with electrical soil moisture instruments.2/ The measurements make it possible to determine water movement into and through the soil as well as evaporative losses from the soil and plants growing in the lysimeters.

To study effects of unnatural soil drainage and restricted root development upon the growth of plants and their use of water in the large "confined" lysimeters, additional records of surface runoff and soil moisture are obtained from five "unconfined" lysimeters. The latter consist of pits 17-1/2 feet square and 7 feet deep, filled with lysimeter soil and planted to five of the species growing in the "confined" lysimeters.

7. Physical Features--Inventories and maps have been prepared of the vegetation, soil, geology, and topography of the Forest. Analysis of streamflow and erosion data for each of the Forest watersheds is evaluating the influence of these physical features, and the climate, upon waterflow and soil movement.

Study of Watershed Management

Studies of watershed management include tests of the following improvement measures:

2/ The fiberglas electrical soil-moisture instrument, developed on the San Dimas Forest, consists of a soil unit buried permanently at the point where moisture measurement is required, and a portable meter to measure electrical resistances of elements within the soil unit. Soil moisture and temperature are determined from these measurements.

1. Changes in Watershed Vegetation--Studies of rainfall disposition and soil movement on slopes under several types of vegetation have been started on the runoff plots. Behavior of the Bell and Fern small watersheds is being observed for a period of years, after which the vegetation on some of them will be changed. Measurements of water yield, flood runoff, and soil movement from the treated watersheds will then be compared with similar measurements made on the watersheds left undisturbed. Vegetation on the Bell watersheds has not been burned since 1919. The Fern watersheds had been unburned for more than 50 years prior to 1938 when a fire swept over this area. Records obtained before and after this accidental treatment showed that storm runoff and erosion were increased greatly for three years after the fire. Another wildfire in 1953 burned over the upper one-third of Wolfskill Canyon (Intermediate watershed I), which has an area of 1,525 acres. The vegetation on this watershed had not been damaged for at least 50 years prior to the 1953 fire. Rainfall and streamflow records obtained from Wolfskill Canyon and other watersheds on the San Dimas Forest for 17 years before the fire were compared with similar records obtained after the fire. These records indicate that the debris-laden peak flow from Wolfskill Canyon during the first large post-fire storm of approximately 6 inches rainfall was more than 100 times as great as would have been expected had the watershed not been partially burned.

2. Management of Stream Bottom Vegetation--It is known that alders, willows, sycamores, and other plants found in stream channels use much water. Complete removal of this vegetation would eliminate water use by the plants, but the loss of shade would increase evaporation from the water and soil. Studies are to be made to determine the species and amount of vegetation that will result in the minimum loss of water from stream bottoms and still provide bank protection during high flows. Some of the studies in this investigation will be conducted in lysimeters. Others will require altering the vegetation in stream channels where records of streamflow can be compared for periods before and after treatment.

3. Engineering Improvements--Studies are to be made of the effects of small dams and retaining walls built in stream channels on total streamflow yield and flood peaks, as well as the stability of soil and rock material in the channels and on adjacent slopes. Effects of the engineering improvements can be determined by comparing hydrologic records from treated and untreated watersheds before and after the improvements are made.

Corollary Watershed Research

Other Forest Service watershed studies have been completed or are in progress elsewhere in southern California. Among the completed studies are: (1) erosion control methods for mountain roads, (2) the "first aid" seeding of burned watersheds, and (3) an appraisal of flood and erosion damages resulting from watershed fires. Now in progress are studies of soil movement on watershed slopes and of vegetation treatment methods designed to reduce this movement. These studies are being carried on in cooperation with the Angeles National Forest on field plots in the Los Angeles River watershed.

THE SAN DIMAS EXPERIMENTAL FOREST

Watershed Areas

Watershed	Drainage area: Square miles	Drainage area: Acres	Range in elevation
		MAJOR	
San Dimas	15.75	10,080	1500-5500
Big Dalton	4.46	2,855	1700-3500
		INTERMEDIATE	
San Dimas			
I Wolfskill	2.39	1,530	1700-5200
II Fern	2.14	1,370	2600-5500
III Upper East Fork	2.14	1,370	2600-5200
IV East Fork	5.48	3,510	1900-5500
V North Fork	4.23	2,710	1900-4500
VI Main Fork	13.14	8,410	1600-5500
VII West Fork	1.72	1,100	1600-3100
Total XII (San Dimas)	15.75	10,080	
Dalton			
VIII Bell	1.36	870	1900-3500
IX Volfe	1.16	740	1900-3500
X Monroe	1.37	875	1800-3400
Total XI (Dalton)	4.46	2,855	
		SMALL	
Bell			
No. 1	0.121	77	2500-3400
No. 2	0.158	100	2500-3500
No. 3	0.097	62	2500-3400
No. 4	0.058	37	2500-3100
Total	0.434	276	
Fern			
No. 1	0.055	35	4500-5400
No. 2	0.063	40	4500-5400
No. 3	0.084	53	4500-5400
Total	0.202	128	